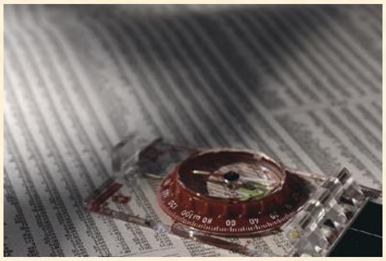
FACT SHEET



SENSITIVITY AND UNCERTAINTY

Understanding the Input and Output Variability of a System Model

Highlights

Why is Uncertainty Analysis Important?

- Provides decision makers with an assessment of overall model accuracy.
- Documents the variability in each input value.
- Enables “rolling up” of uncertainty in input values into uncertainty in output measures.

Why is Sensitivity Analysis Important?

- Investigates the robustness of the model.
- Allows the modeler to assess the impact of modeling assumptions.
- Determines which of the modeling input uncertainties have the greatest effect on model output measure uncertainty.
- Provides insight into how the system behaves in response to changes in input values.
- Gives analysts understanding of the interaction of multiple input factors.

What are the Research Areas?

- Sensitivity and uncertainty analysis is applicable to any study accomplished using a mathematical or computer model such as those commonly used in military logistics, manufacturing, and energy production applications.

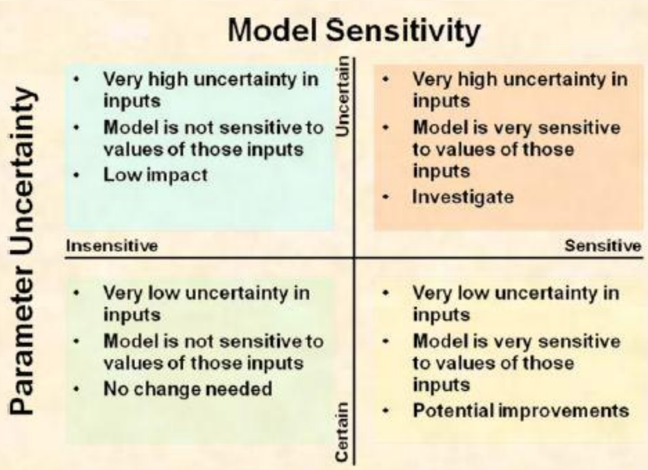
Sensitivity and Uncertainty Analysis Overview

Sensitivity and uncertainty analysis is often thought of as one activity, relating to the study of variability in a system model. It actually represents two distinct concepts, each with their own purpose, that are frequently explored simultaneously.

Uncertainty analysis attempts to quantify the uncertainty in the outputs of a model that result from model assumptions and uncertainty in model input values. It reflects the uncertainty in the conclusions of the study.

Sensitivity analysis tries to identify how variation in input values relates to variation in output measures. It is performed by changing an input variable or combinations of input variables and observing the effect on output measures. It is performed on inputs that are estimates as well as those that are known with great accuracy. This type of analysis is useful for identifying potential modifications to a system to improve performance.

The two types of analyses are complementary. Sensitivity analysis determines which of the input uncertainties matter most.



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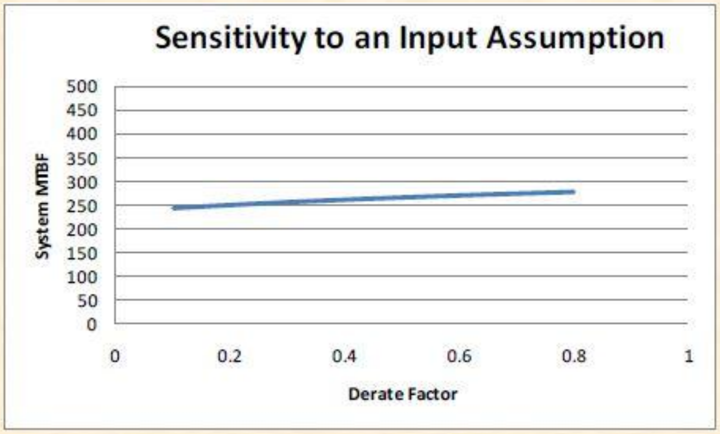
Sensitivity and Uncertainty

Sensitivity Example

A newly designed system will be installed in a helicopter. A reliability model was constructed to predict system level mean time between failures (MTBF) based on the component level inputs. Some of the component MTBF values were based on previous use in a fixed wing aircraft. To account for the harsher environment of rotary wing flight each of those MTBFs were multiplied by 0.3, which is a typical de-rating factor for that type of environment change. What if the observed performance of the components selected is not typical?



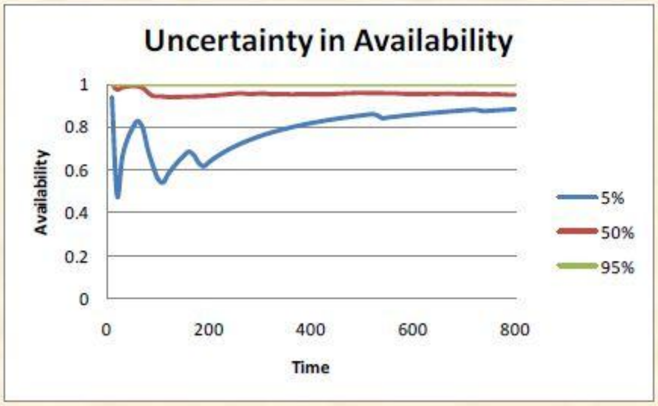
The de-rating factor, which was applied to a subset of the components, was varied across a range of reasonable values and found to not cause significant changes in the system MTBF.

Uncertainty Example

Limited Duration Employment

A system comprised of <u>exponentially distributed components</u> is deployed for a short duration mission. The mean time to failure and the mean time to repair of each component are well characterized from years of system use, and the system availability is known to be 0.945. Can the operator expect to observe the known availability during the deployment?

Uncertainty Example (continued)

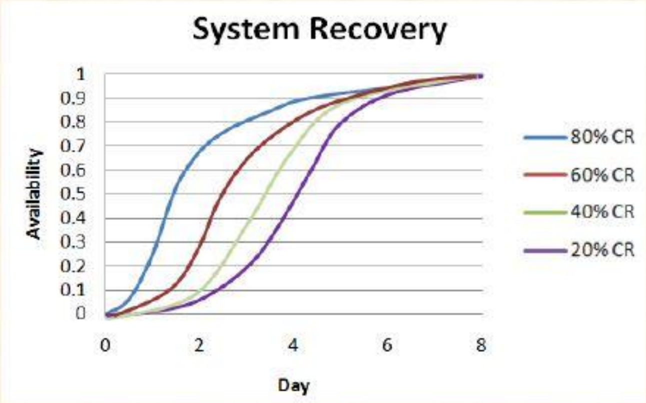


The reported availability is a steady state value which is realized after extended operations. Because of the exponential nature of the components, there is uncertainty in the expected availability during deployments which varies depending on the length of the mission. This uncertainty would be present even if the inputs parameters are known exactly.

Sensitivity and Uncertainty Example

System Recovery from a Maintenance Event

A model was constructed to predict availability during the recovery period following a mission. Recovery is dependent on an uncertain input value describing the percentage of failures that are crew repairable (CR).



The uncertain input parameter was varied over a range of likely values and the resulting graph shows the range in expected availability, illustrating the sensitivity to the uncertainty in the input values.

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